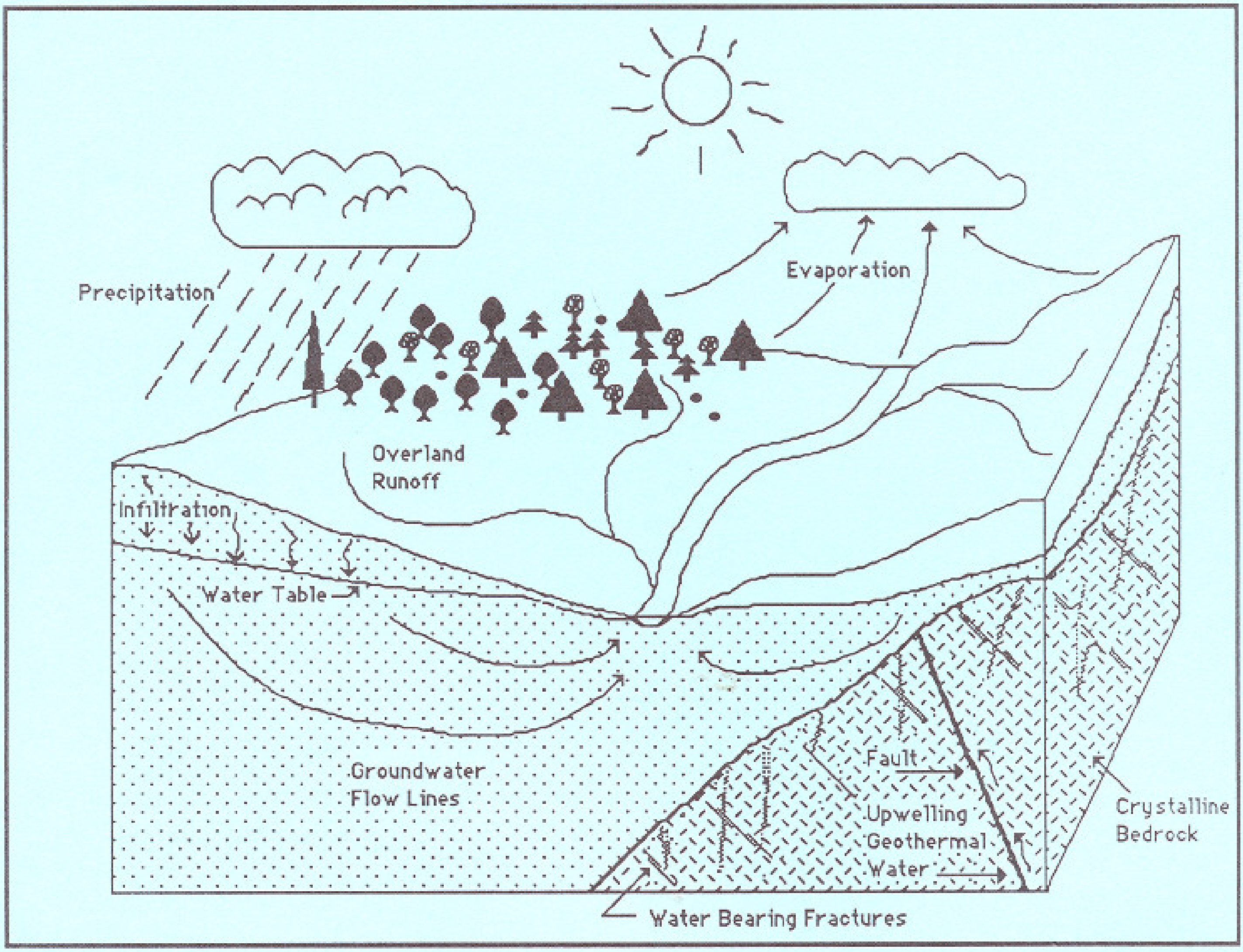
IDAHO GROUNDWATER QUALITY PROTECTION

A MANUAL FOR LOCAL OFFICIALS



IDAHO DEPARTMENT OF HEALTH AND WELFARE
DIVISION OF ENVIRONMENTAL QUALITY
BUREAU OF WATER QUALITY

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IDAHO GROUNDWATER QUALITY MANAGEMENT
A MANUAL FOR LOCAL OFFICIALS

PREPARED BY
PAUL JEHN

IDAHO DEPARTMENT OF HEALTH AND WELFARE
DIVISION OF ENVIRONMENTAL QUALITY
BUREAU OF WATER QUALITY

450 WEST STATE STREET
BOISE, ID 83720-9990

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INTRODUCTION

Groundwater is one of Idaho's most important and fragile natural resources. Idaho is the fourth largest user of groundwater in the United States; groundwater supplies over 90 percent of the state's drinking water. Traditionally, man has disposed of his waste products in a variety of ways, sometimes with little thought for its potential impacts on groundwater quality. Typically, disposal represented convenience, expedience, expense or best available technology. Until recently, groundwater was largely thought to be immune from pollution. Past practices which were thought to be quite benign are now known to cause serious groundwater pollution problems. Groundwater pollution may lead to nuisance problems like hardness, color, taste, odor or appearance. More serious problems develop when the pollutants are pathogenic organisms, flammable or explosive substances or toxic chemicals. The long-term health effects of some of these substances are largely unknown.

Polluted groundwater generally does not cover large areas. Because groundwater moves at relatively low velocities, extensive mixing and dilution of contaminant plumes by groundwater is low. A contaminant plume may maintain a high degree of concentration as it moves from its source downgradient to its discharge point.

Groundwater quality in Idaho is generally very good. However, local problems have arisen which suggest that prudent management of this natural resource is imperative. The most promising action now available is prevention of contamination.

Groundwater quality protection is everyone's responsibility. Local governments can play a decisive role in groundwater quality assurance by providing leadership in protecting this vital and vulnerable natural resource. Nationwide, local governments are designing groundwater quality management programs tailored to their specific needs. There are numerous methods that localities can utilize to prevent contamination of their groundwater supplies. Groundwater management methods are based on an understanding of the resource involved and the knowledge and ability to utilize protection techniques.

The goal of this manual is to provide local officials with the tools to protect the quality of their groundwater. Included in this document are sections describing basic hydrology, sources of groundwater contamination and detailed descriptions on local groundwater quality management options, including examples successfully employed nationwide.

Since each community has differing groundwater conditions, technical assistance may be needed. The Idaho Division of Environmental Quality (DEQ) has been designated as having lead responsibility for groundwater quality management within Idaho. The Groundwater Unit of DEQ provides both planning and technical assistance statewide for all groundwater quality related issues.

An understanding of the basic concepts which govern the movement of groundwater is essential for groundwater quality management. Groundwater forms a part of the hydrologic cycle, which is a constant movement of water above, on and below the earth's surface. This cycle replenishes groundwater supplies through precipitation and infiltration (Figure 1). Evaporation or evapotranspiration from snow fields, lakes, rivers, vegetation and exposed wetland surface feeds the cycle. As the water vapor rises, it condenses to form clouds and precipitation which returns the water to the land surface. As precipitation falls, it can be stored as snow, infiltrate into the earth or run off into rivers and lakes. The amount of precipitation that infiltrates versus the amount that forms runoff varies widely and is dependent on such factors as the rate of precipitation, vegetation cover, degree of slope, soil composition and the amount of moisture already in the soil.

At first, infiltration is absorbed by the soil. Once saturated, the moisture passes through the soil horizon, through the unsaturated zone and to the water table. The unsaturated zone is almost always underlain by a zone in which all the interconnected openings are full of water. The water in this zone, groundwater, is available to supply wells and springs.

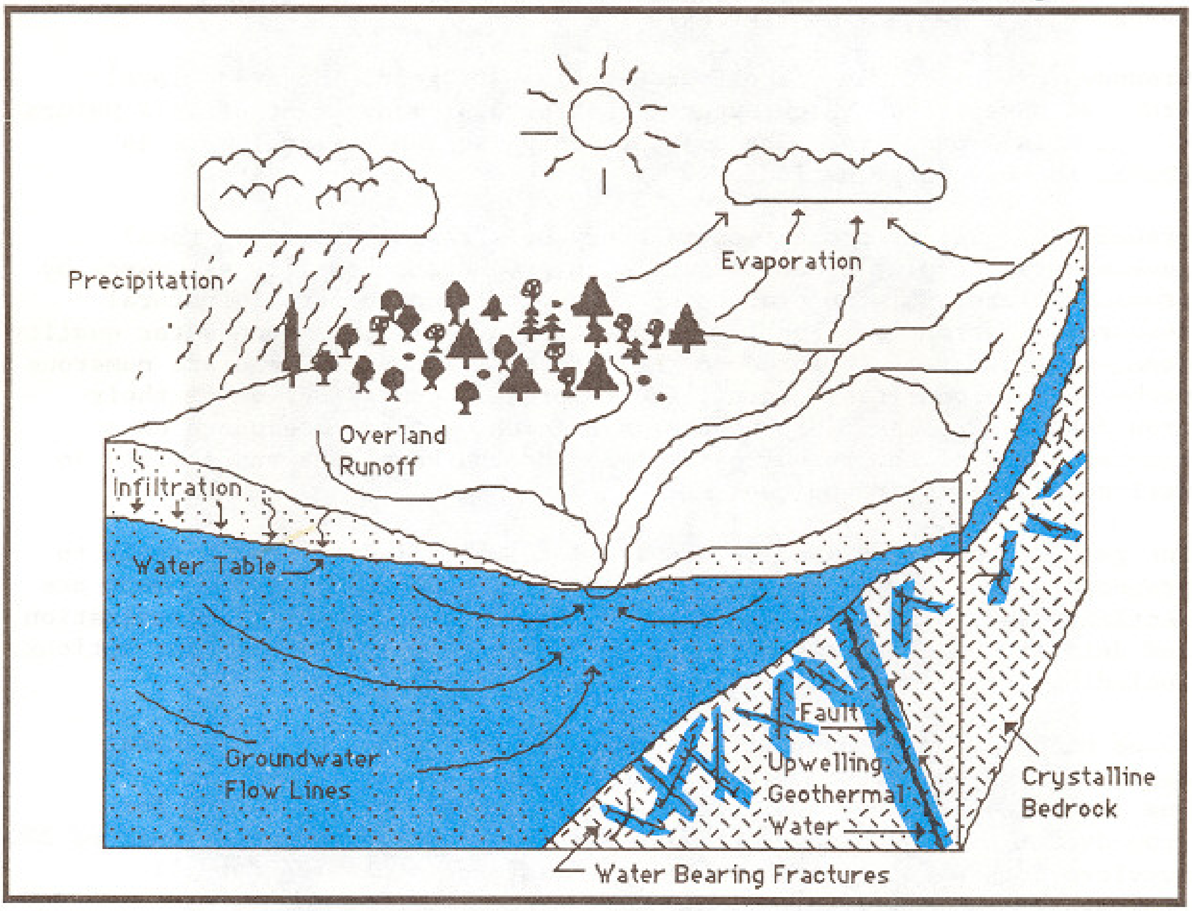

Figure 1. The Hydrologic Cycle

Since most water which is recharged to the water table passes through the unsaturated zone, this zone is extremely important to water quality. The unsaturated zone is divided into the soil zone, the intermediate zone and the periodically saturated zone (Figure 2). The rate of infiltration, or recharge, through the unsaturated zone is dependent on soil and rock type. A well-developed soil horizon can be an effective method for preventing groundwater contamination. Initially, the soil may filter out the larger particles from a contaminant source. The soil layer can also selectively sorb different contaminants. This can be both in the form of surface adhesion (adsorption) or interatomically (absorption by clays and carbon). Biodegradation can also play an important role. In the upper ten inches of soil, bacteria exist which can degrade pesticides and petroleum products. Materials such as nitrogen from fertilizers and heavy metals such as cadmium can be taken up by plants. The absence of well-developed soil layers provides a more direct pathway for contaminants to reach groundwater.

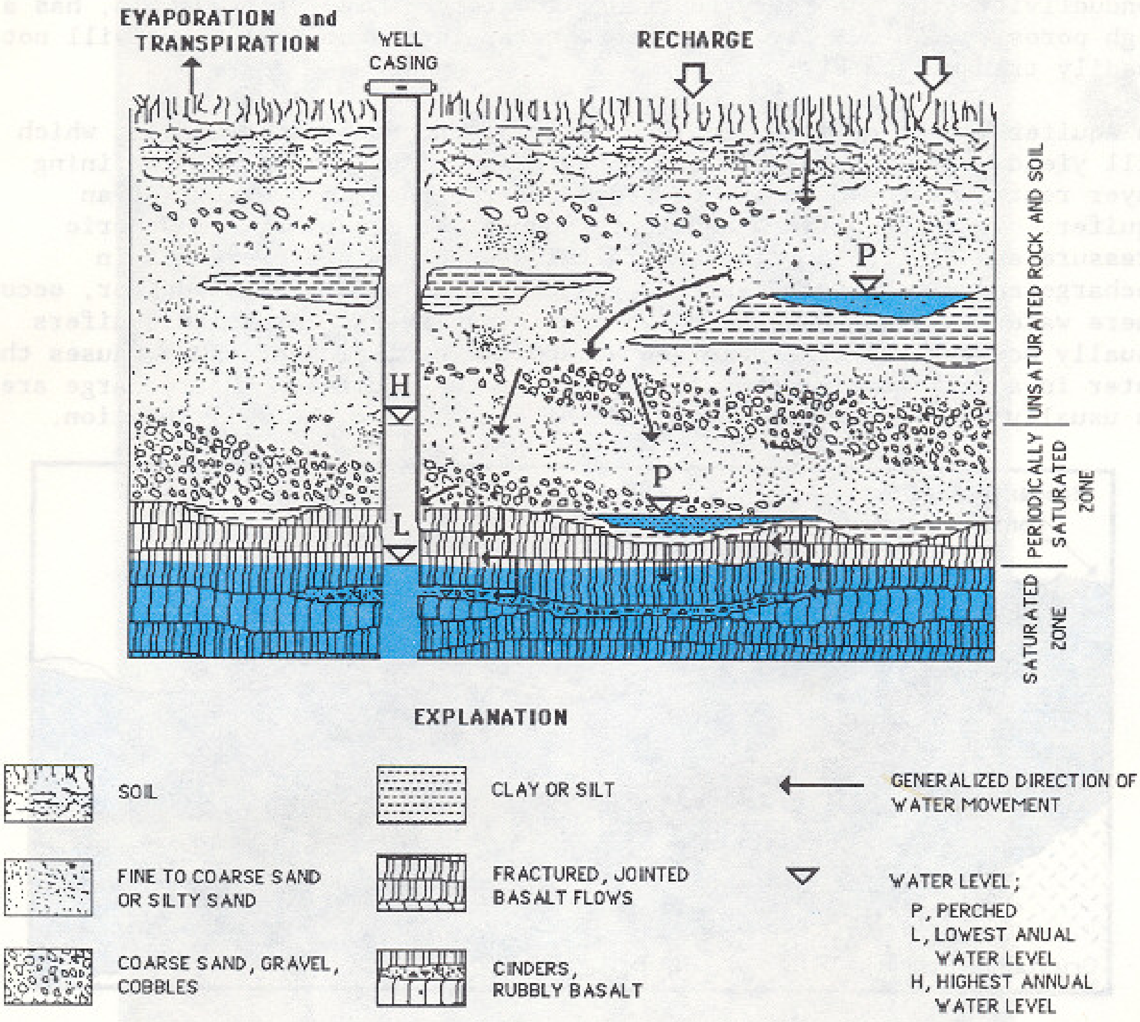

Figure 2. The Relationship of the Saturated and Unsaturated Zones

A recharge area is where water from precipitation or surface runoff is transmitted downward to the water table. Groundwater occurs below the water table where all the available pore space is filled with water. The water table conforms roughly to the surface topography, but tends to be deeper under hills and shallower in the valleys. Water will continue to migrate downward, under the force of gravity, until it reaches the water table or encounters an impermeable or confining layer. Hydraulic conductivity or permeability is a measure of how readily a unit will transmit water. Confining layers of low hydraulic conductivity may contain water but will not transmit or yield usable quantities of water. Porosity is a measure of the amount of openings or voids in a soil or rock unit. These openings may be in the form of spaces in sand and gravel beds, fractures in granite or basalt or voids such as lava tubes or fissures in basalt flows. Unconsolidated sand and gravel beds have a high porosity (10-30%), whereas granite has a low porosity (0-10%). A unit may have a high porosity (the ability to hold a lot of water) and a low hydraulic conductivity (the inability to transmit water). Clay, for example, has a high porosity (40-50%; it will absorb water interatomically) but will not readily transmit water.

An aquifer may be defined as a rock unit or unconsolidated deposit which will yield water in a usable quantity to a well or spring. A confining layer restricts the movement of groundwater either into or out of an aquifer. In an unconfined aquifer, groundwater occurs at atmospheric pressure and is free to rise and fall in response to differences in recharge and discharge (Figure 3). A confined, or artesian aquifer, occurs where water is trapped between two confining layers. Artesian aquifers usually occur at considerable depth, and the confining pressure causes the water in a well to rise above the level of the aquifer. The recharge area is usually miles (sometimes hundreds of miles) from the well location.

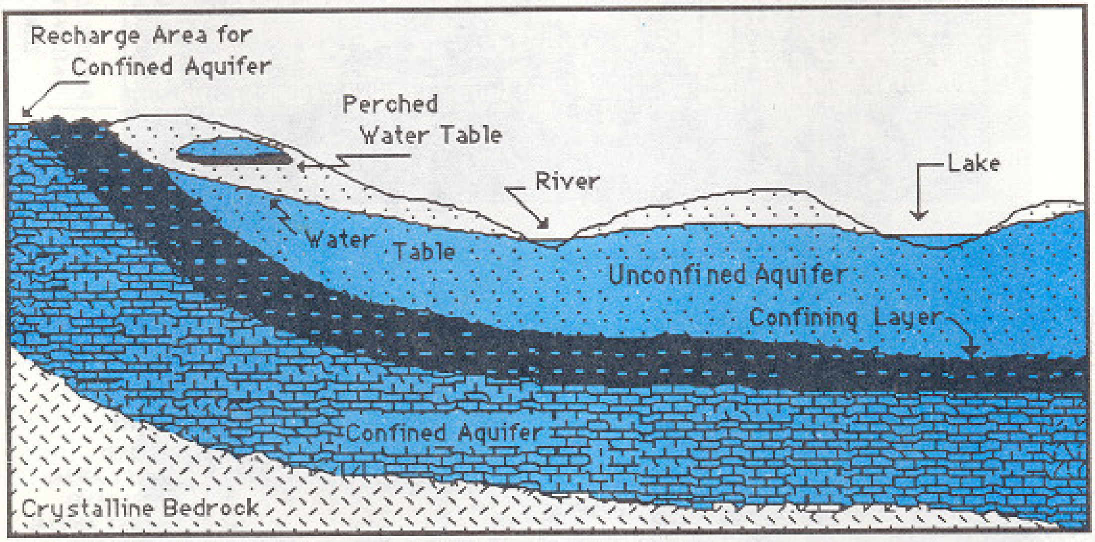

Figure 3. Confined and Unconfined Aquifers

When a well is drilled into an unconfined aquifer, the water level is generally at the same level as the upper surface of the aquifer. This is, in most cases, the water table. By contrast, when a well is drilled into a an artesian aquifer, the water level in the well will be some height above the top of the aquifer and perhaps will be flowing on the land surface.

Perched water tables occur in unconfined aquifers and result when a localized confining layer occurs within a more permeable media (e.g., a clay lense in a sand and gravel deposit). These perched layers may produce water of different quantities and quality than water in the underlying aquifer.

GROUNDWATER MOVEMENT

Groundwater moves through an aquifer under the force of gravity. In the recharge area, this causes water to move downward toward aquifers. Aquifers are recharged through precipitation, leakage from streams, valley underflow, irrigation, injection wells and septic systems. Recharge by precipitation is the direct infiltration of rain or snowmelt into the aquifer. Valley underflow occurs when tributary streams and their underlying aquifers enter a larger aquifer. Irrigation results in direct infiltration. Injection wells gather storm water and irrigation tail water and transmit it directly to the aquifer via wells. Effluent from septic drainfields filters through the unsaturated zone to the water table. Discharge from an aquifer occurs from pumping, river gains, spring discharge, evaporation and utilization of water by plants. Aquifers transmit water from recharge areas to discharge areas and serve as tremendous storage areas for groundwater.

The velocity at which groundwater moves is dependent upon three variables: permeability (hydraulic conductivity), porosity, and hydraulic gradient. The aquifer media controls the porosity and hydraulic conductivity. The hydraulic gradient is the slope of the water table in unconfined aquifers. The slope of the water table may be determined by measuring the depth to water in different wells. Water movement is down gradient and, depending upon the aquifer, may move only a couple of hundred feet a year to, in extreme cases, a few miles a year.

In the saturated zone, groundwater movement is generally laminar. In laminar flow, water moves along in an orderly and generally streamlined manner. Therefore, when pollutants are introduced into an aquifer, to a certain degree, they will be confined to well defined flow paths. Dispersion does occur but to only a minor degree under idealized conditions. Contaminants which are lighter than water (e.g., petroleum products) tend to float on the surface of the aquifer while contaminants which are heavier than water (e.g., brines from road salt stockpiles) tend to sink to the bottom of the aquifer (Figure 4).

Pumping of water from wells locally disrupts the pattern of groundwater movement. When water is withdrawn from a well, water is drawn from the aquifer into the well and lowers the water table around the well. This cone of depression is a funnel-shaped drop in the water table. Within the cone of depression, all water flows into the well. In studies relating to groundwater contamination, the cone of depression becomes critical because water is drawn in from all directions and the corresponding increase in hydraulic gradient and velocity may draw pollutant into the well faster than overall aquifer analysis may indicate. The size of the cone is dependent on the rate at which water is withdrawn from the well, aquifer properties at the well, and the velocity at which water moves through the aquifer.

Sometimes the cone of depression from one well will overlap that of another well. When this happens, the well with the wider, deeper cone of depression could draw water away from the smaller well. Wells which pump large volumes of water may locally change the direction of groundwater flow (Figure 5).

GROUNDWATER SYSTEMS IN IDAHO

The main types of aquifers occurring in Idaho are composed of unconsolidated sedimentary deposits, basalt, or a combination of sedimentary and volcanic deposits (Figure 6).

Valley-fill aquifers are composed of unconsolidated sedimentary materials in intermountain valleys. They yield sufficient water for domestic use and farming activities. In northern Idaho, these aquifers consist of glacial outwash with some recent alluvium. The principal aquifer is the Spokane Valley-Rathdrum Prairie Aquifer. This aquifer has extremely high transmissivities (the ability for groundwater to move) which result in very low drawdown in high-yielding wells.

Basalt aquifers are characterized by numerous basalt flows and thin, interbedded sediments. The principal aquifer of this type and also the principal aquifer in Idaho is the Snake Plain Aquifer which extends from Ashton to Bliss. This aquifer system discharges nearly 8 million acre feet annually to the Snake River. The Snake Plain Aquifer is one of the most productive aquifers in the nation.

Two smaller basalt aquifers occur in the Lewiston-Moscow area and the Weiser River Basin. Although they have much smaller yields than the Snake Plain Aquifer, they provide most of the domestic water and significant agricultural water for their regions.

Sedimentary and volcanic aquifers, which occur chiefly in the western Snake Plain, are composed of gravels, sand, silt and clay, interbedded with basalt, shale, and sandstone. Significant geothermal waters are found in some areas of these aquifers. Such systems are found in the Boise Valley, Mountain Home area and south of the Snake River at Buhl and Twin Falls. These geothermal systems are formed by the upwelling of heated water along faults and fissures.

The principal recharge to Idaho aquifers is from snowmelt via streams and rivers. Only 2 to 5 percent of the recharge is attributed to precipitation directly over the aquifers. Recharge from man’s activities impacts groundwater quantity and quality. Percolation of irrigation waters, return flows through injection wells, land-applied wastewaters and septic tank systems all have the potential to adversely affect groundwater quality.